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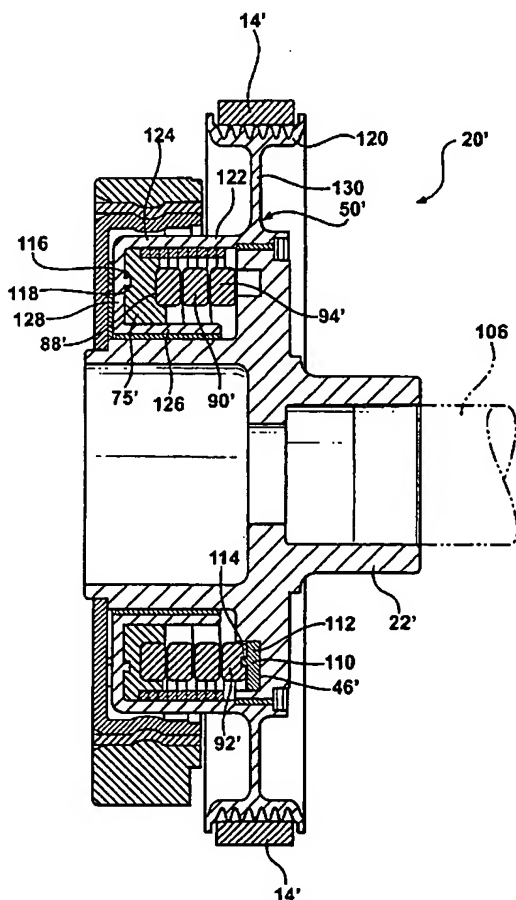
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(54) Title: OVERRUNNING ALTERNATOR DECOUPLER PULLEY WITH BARE WIRE SPRING AND GREASE LUBRICATION



(57) Abstract: A decoupler assembly (20) is provided for allowing an alternator to be rotatably driven by a serpentine belt (14) in an engine of an automotive vehicle and for allowing the speed of the belt to oscillate relative to the alternator. A hub is fixedly carried by a drive shaft (15) from the alternator for rotation therewith. A pulley (50) is rotatably journaled to the hub by a ball bearing member (55). The ball bearing member includes lubricant for minimizing frictional wear therein. A bare, helical clutch spring (71) is operatively coupled between the hub and pulley for transferring rotational movement from the pulley to the hub during acceleration of the pulley relative to the hub by the serpentine belt and for allowing the hub to overrun the pulley during deceleration of the pulley relative to the hub.

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10/581097
AP3 Rec'd PCT/PTO 31 MAY 2005**OVERRUNNING ALTERNATOR DECOUPLER PULLEY WITH BARE WIRE
SPRING AND GREASE LUBRICATION****Field of the Invention**

5 The invention relates to a belt drive assembly for driving belt driven accessories in an engine of an automotive vehicle, and more particularly, to a decoupling mechanism for allowing the belt driven accessories to operate temporarily at a speed other than the belt drive assembly.

10 Description of the Prior Art

 It is widely known in an automotive vehicle engine to transfer a portion of the engine output to a plurality of belt driven accessories utilizing an endless serpentine belt. Typically, each component includes an input drive shaft and a pulley coupled to a distal end of the drive shaft for driving engagement with the belt. An example of such a belt driven accessory is an
15 alternator.

 It is also known to provide a decoupler operatively coupled between the pulley and the alternator to allow the alternator drive shaft to "overrun" or rotate at a faster speed than the pulley and to allow the speed of the pulley to oscillate with respect to the alternator drive shaft due to oscillations in the engine speed.

20 Examples of decouplers are disclosed in the United States Patent 6,083,130, issued to Mevissen et al. on July 4, 2000 and the United States Patent 5,139,463, issued to Bytze et al. on August 18, 1992.

 It remains desirable to provide a decoupler that is easier to manufacture and has better durability over conventional decoupler designs.

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SUMMARY OF THE INVENTION

According to one aspect of the invention, a decoupler assembly is provided for transferring torque between a shaft and a drive belt. The decoupler assembly includes a hub configured to be fixedly secured to the shaft. The hub includes a helical first slot formed therein. A carrier is rotatably mounted on the hub. The carrier includes a helical second slot formed therein. A torsion spring extends between a hub end and a carrier end for transferring torque between the hub and carrier, wherein the hub end is retained in the helical first slot to prevent relative movement between the hub end of the torsion spring and the hub and the carrier end is retained in the helical second slot to prevent relative movement between the carrier end of the torsion spring and the carrier. A pulley is rotatably coupled to the hub. The pulley includes an outer surface configured to frictionally engage with the drive belt. The pulley has an inner surface formed therein. A clutch spring is fixedly secured to the carrier and has a plurality of helical coils frictionally engaging with the inner surface of the pulley to selectively couple the hub and pulley. The torsion spring and the clutch spring are wound in opposite senses enabling the clutch spring to expand into gripping engagement with the inner surface during acceleration of the pulley relative to the hub and to contract out of gripping engagement with the inner surface during deceleration of the pulley relative to the hub.

BRIEF DESCRIPTION OF THE DRAWINGS

Advantages of the present invention will be readily appreciated as the same becomes better understood by reference to the following detailed description when considered in connection with the accompanying drawings wherein:

Figure 1 is a front view of an engine of an automotive vehicle incorporating a decoupler assembly according to one aspect of the invention;

Figure 2 is an enlarged fragmentary sectional view of the decoupler assembly;

Figure 3 is a perspective view of a clutch spring in the decoupler assembly;

Figure 4 is a perspective view of a carrier for carrying one end of the clutch spring in the decoupler assembly;

Figure 5 is a perspective view of the clutch spring assembled to the carrier;

5 Figure 6 is an exploded perspective view of the decoupler assembly according to a second embodiment of the invention;

Figure 7 is a cross sectional view of the decoupler assembly according to the second embodiment of the invention; and

10 Figure 8 is a cross sectional view of the decoupler assembly according to a third embodiment of the invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring to the figures, an engine for an automotive vehicle is generally indicated at 10 in Figure 1. The engine 10 includes a crankshaft 12 driving an endless serpentine belt 14, as commonly known by those having ordinary skill in the art. The engine 10 also includes a belt driven accessory 16 driven by the belt 14. Described in greater detail below, a decoupler assembly 20 is operatively assembled between the belt 14 and the belt driven accessory 16 for automatically decoupling the belt driven accessory 16 from the belt 14 when the belt 14 decelerates relative to the belt driven accessory 16 and allowing the speed of the belt 14 to oscillate relative to the belt driven accessory 16. Additionally, a detailed description of the structure and function of a decoupler assembly can be found in applicant's United States Patent 6,083,130, which issued on July 4, 2000 and is incorporated herein by reference in its entirety.

Referring to Figure 2, the decoupler assembly 20 includes a hub 22 having opposite first 24 and second 26 ends and a generally cylindrical body 28 extending axially

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therebetween. The body 28 includes opposite inner 30 and outer 32 surfaces extending between the first 24 and second 26 ends of the hub 22. The inner surface 30 includes a plurality of inner threads 33 adjacent the first end 24 for fixedly securing the hub 22 to a drive shaft 15 from the belt driven accessory 16. A reduced diameter portion 34 is formed in
5 the first end 24. The reduced diameter portion 34 includes an outer mounting surface 36 having a smaller outer diameter than the body 28. An abutment surface 38 opposite the second end 26 extends generally radially between the outer mounting surface 36 and the body 28. An annular thrust washer 39 is seated on the outer mounting surface 36 adjacent the abutment surface 38.

10 A socket 40 is formed in the second end 26 for receiving a suitable tool therein for rotatably threading the hub 22 onto the drive shaft 15. An annular first flange 41 extends radially outwardly from the body 28 adjacent the second end 26. The first flange 41 includes an outer flange surface 42 having a larger outer diameter than the body 28. An annular surface 44 extends generally radially between the body 28 and the outer flange surface 42
15 opposite the second end 26. A generally helical first slot 46 is formed in the annular surface 44 defining a first locating surface 48 therein.

A generally cylindrical pulley 50 is rotatably journaled to the hub 22. More specifically, the pulley 50 extends between opposite first 52 and second 54 ends. The pulley 50 includes an inner surface 56 extending between the first 52 and second 54 ends. A ball
20 bearing member 57 is coupled between the pulley 50 and the hub 22. The bearing member 57 includes an inner race 58 fixedly secured to a portion of the outer mounting surface 36 and an outer race 59 fixedly secured to a portion of the inner surface 56 adjacent the first end 52 of the pulley 50. A plurality of ball bearings 55 is rollingly engaged between the inner 58 and outer 59 races of the bearing member 57. A cylindrical bushing 60 is journal mounted
25 between the pulley 50 and the first flange 41. The bushing 60 includes a sleeve wall 62

extending between a portion of the inner surface 56 adjacent the second end 54 and the outer flange surface 42 of the first flange 41. A bushing 64 extends radially inwardly from the sleeve wall 62 and abuts the annular surface 44 in the first flange 41.

The pulley 50 includes an outer periphery 66 with a plurality of V-shaped grooves 68
5 formed therein for rollingly engaging and guiding the belt 14.

Referring to Figures 2-5, a one-way clutch assembly 70 is operatively coupled between the hub 22 and the pulley 50. The clutch assembly 70 includes a clutch spring 71 and a carrier 75. The clutch spring 71 includes a plurality of helical coils 72 extending between a bent or hooked proximal end 73 and an opposite distal end 74. Preferably, the
10 clutch spring 71 is formed from an uncoated, spring steel material and has a non-circular cross-section to improve frictional contact. Most preferably, the cross-section of clutch spring 71 is rectangular or square. The clutch spring 71 is press fitted into frictional engagement with the inner surface 56 of the pulley 50. Preferably, a lubricant similar or compatible with grease used in the ball bearing member 57 is applied to minimize wear
15 between the clutch spring 71 and the inner surface 56 of the pulley 50.

The carrier 75 is rotatably mounted on the hub 22. The carrier 75 is generally ring shaped and extends axially between opposite first and second sides 76, 78. A hooked slot 84 is formed in the second side 78 of the carrier 75 and is configured to retain the hooked proximal end 73 of the clutch spring 71. A generally helical second slot 86 is formed in the
20 second side 78 of the carrier 75 defining a second locating surface 88 generally opposing the first locating surface 48 formed in the annular surface 44.

Referring to Figure 2, a helical torsion spring 90 extends between hub 92 and carrier 94 ends. The torsion spring 90 is axially compressed between the first 48 and second 88 locating surfaces for transferring torque between the hub 22 and the carrier 75. More
25 specifically, the hub end 92 of the torsion spring 90 is retained in the first slot 46 of the hub

22. Similarly, the carrier end 94 of the torsion spring 90 is retained in the second slot 86 in the second side 78 of the carrier 75. Axial forces due to the compression of the torsion spring 90 retains the first side 76 of the carrier 75 in abutting engagement with the thrust washer 39. The torsion spring 90 also allows relative movement between the carrier 75 and the hub 22 to
5 accommodate changes in the speed of the pulley 50 due to generally oscillating changes in the operating speed of the engine. The torsion spring 90 and the clutch spring 71 are coiled in opposite directions.

A cap 100 is fixedly assembled to a flange 102 formed in the pulley 50 for preventing contaminants from entering the decoupler assembly 20 and for retaining the lubricant within
10 the decoupler assembly 20.

In operation, the engine 10 is started and the pulley 50 is accelerated and rotated in a driven direction by the belt 14 driven by the engine 10. Acceleration and rotation of the pulley 50 in the driven direction relative to the hub 22 creates friction between the inner surface 56 of the pulley 50 and preferably all of the coils 72 of the clutch spring 71. It should
15 be appreciated that the clutch spring 71 will function even where at the onset at least one of the coils 72 of the clutch spring 71 is frictionally engaged with the inner surface 56 of the pulley 50. The clutch spring 71 is helically coiled such that the friction between the inner surface 56 of the pulley 50 and at least one of the coils 72 would cause the clutch spring 71 to expand radially outwardly toward and grip the inner surface 56 of the pulley 50. Continued
20 rotation of the pulley 50 in the driven direction relative to the hub 22 would cause a generally exponential increase in the outwardly radial force applied by the coils 72 against the inner surface 56 until all of the coils 72 of the clutch spring 71 become fully brakingly engaged with the pulley 50. When the clutch spring 71 is fully engaged with the inner surface 56, the rotation of the pulley 50 is fully directed toward rotation of the drive shaft 15 of the belt

driven accessory 16. Additionally, centrifugal forces help to retain the clutch spring 71 in braking engagement with the inner surface 56 of the pulley 50.

The rotational movement of the carrier 75 in the driven direction is transferred to the hub 22 by the torsional spring 90 such that generally the carrier 75, thrust washer 39, hub 22, and the drive shaft 15 from the belt driven accessory 16 rotate together with the pulley 50. Additionally, the torsional spring 90 resiliently allows relative movement between the carrier 75 and the hub 22 to accommodate oscillations in the speed of the pulley 50 due to corresponding oscillations in the operating speed of the engine 10.

When the pulley 50 decelerates, the hub 22 driven by the inertia associated with the rotating drive shaft 15 and the rotating mass within the belt driven accessory 16 will initially "overrun" or continue to rotate in the driven direction at a higher speed than the pulley 50. More specifically, the higher rotational speed of the hub 22 relative to the pulley 50 causes the clutch spring 71 to contract radially relative to the inner surface 56 of the pulley 50. The braking engagement between the clutch spring 71 and the pulley 50 is relieved, thereby allowing overrunning of the hub 22 and drive shaft 15 from the belt driven accessory 16 relative to the pulley 50. The coils 72 may remain frictionally engaged with the inner surface 56 while the pulley 50 decelerates relative to the clutch assembly 70 and the hub 22. The coils 72 of the clutch spring 71 begin to brakingly reengage the inner surface 56 as the pulley 50 accelerates beyond the speed of the hub 22.

Referring to Figures 6 and 7, a second embodiment of the decoupler assembly 20' is shown, wherein elements of the alternative embodiment similar to those in the first embodiment are indicated by primed reference characters. The decoupler assembly 20' is assembled between an output or crankshaft 106 of an engine and the belt 14' to allow the belt 14' to overrun the crankshaft 106. The decoupler assembly 20' includes a generally ring-

shaped spring support 110. The slot 46' of the hub 22' has a generally U-shaped cross section for retaining the spring support 110 therein.

A first tab 112 extends outwardly from the spring support 110. A first notch 114 is formed in the hub end 92' of the torsion spring 90' for axially receiving the first tab 112 therein. Engagement between the first tab 112 and the first notch 114 prevents relative rotational movement of the hub end 92' of the torsion spring 90' relative to the spring support 110 and hub 22'. Similarly, a second tab 116 extends outwardly from the second locating surface 88' of the carrier 75'. A second notch 118 is formed in the carrier end 94' of the torsion spring 90' for axially receiving the second tab 116 therein. Engagement between the second tab 116 and the second notch 118 prevents relative rotational movement of the carrier end 94' of the torsion spring 90' relative to the carrier 75'.

The pulley 50' includes an outer periphery 120 for seating the belt 14' therein and an inner flange portion 122. The inner flange portion 122 has a generally U-shaped cross section defined by outer 124 and inner 126 pulley walls and a first connecting wall 128 extending radially therebetween. The carrier 75' is retained between the outer 124 and inner 126 pulley walls and the first connecting wall 128 of the inner flange portion 122, such that the carrier 75' rotates with the pulley 50'. A second connecting wall 130 extends radially between the outer pulley wall 124 and the outer periphery 120.

The carrier 75' includes a slot or split 132, which helps the carrier 75' to flex and accommodate loads associated with the rotation of the decoupler assembly 22'.

Referring to Figure 8, a third embodiment of the decoupler assembly 20" is shown, wherein the body 28" and first flange 41" of the hub 22" are formed separately and fixedly connected in a subsequent assembly operation. The body 28" of the hub 22" is generally cylindrical and extends between the first 24" and second 26" ends. The first flange 41" includes a mounting portion 140, which has a center bore 142 for receiving the outer flange

surface 36" of the hub 22" therethrough. The first flange 41" includes a generally U-shaped cross section defined by an end wall 134 extending radially between generally parallel inner 136 and outer 138 flange walls. The spring support 110" is retained between the inner 136 and outer 138 flange walls and the end wall 134, such that the spring support 110" rotates
5 with the first flange 41".

The outer periphery 120" and the inner flange portion 122" of the pulley 50" are formed separately and fixedly connected in a subsequent assembly operation using any suitable method, such as welding. The generally U-shaped cross section of the inner flange portion 122" opens toward the first flange 41". The carrier 75" is retained between the outer
10 124" and inner 126" pulley walls and the first connecting wall 128", such that the carrier 75" rotates with the pulley 50".

A ring plate 143 is mounted concentrically onto the outer mounting surface 36" adjacent the abutment surface 38". A thrust washer 144 is disposed between the first flange 41" and the ring plate 143. The thrust washer 144 is axially spaced apart from the end wall
15 134 of the flange 41" for receiving the inner flange portion 122" of the pulley 50" therebetween.

A torsional vibration damper 146, as known by those skilled in the art, is fixedly secured to the outer flange wall 138 of the first flange 41" for dampening vibrations experienced at the crankshaft 106 associated with the operations of the engine.

20 The invention has been described in an illustrative manner, and it is to be understood that the terminology, which has been used, is intended to be in the nature of words of description rather than of limitation. Many modification and variations of the present invention are possible in light of the above teachings. It is, therefore, to be understood that within the scope of the appended claims, the invention may be practiced other than as
25 specifically described.

What is claimed is:

1. A decoupler assembly for transferring torque between a shaft and a drive belt, said decoupler assembly comprising:

5 a hub configured to be fixedly assembled to the shaft, said hub including a helical first slot formed therein;

a carrier rotatably mounted on said hub, said carrier including a helical second slot formed therein;

a torsion spring extending between a hub end and a carrier end for transferring torque between said hub and carrier, wherein said hub end is retained in said helical first slot to
10 prevent relative movement between said hub end of said torsion spring and said hub and said carrier end is retained in said helical second slot to prevent relative movement between said carrier end of said torsion spring and said carrier;

a pulley rotatably coupled to said hub, said pulley having an outer periphery configured to frictionally engage with the drive belt, said pulley having an inner surface
15 formed therein;

a clutch spring fixedly secured to said carrier and having a plurality of helical coils frictionally engaging with said inner surface of said pulley to selectively couple said hub and pulley, said torsion spring and said clutch spring wound in opposite senses enabling said clutch spring to expand into gripping engagement with said inner surface during acceleration
20 of said pulley relative to said hub and to contract out of gripping engagement with said inner surface during deceleration of said pulley relative to said hub.

2. A decoupler assembly as set forth in claim 1 wherein said hub includes a body extending axially between first and second ends.

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3. A decoupler assembly as set forth in claim 2 wherein said hub includes a cylindrical outer surface extending between said first and second ends.
4. A decoupler assembly as set forth in claim 3 wherein said hub includes a first flange
5 extending radially outwardly from said body to define an outer flange surface having a larger diameter than said body.
5. A decoupler assembly as set forth in claim 4 wherein said second flange includes an annular surface extending radially between said body and said outer flange surface.
- 10 6. A decoupler assembly as set forth in claim 5 wherein said helical first slot is formed in said annular surface for retaining therein said hub end of said torsion spring for preventing relative movement between said hub end of said torsion spring and said hub.
- 15 7. A decoupler assembly as set forth in claim 6 wherein said hub includes a reduced diameter portion having an outer mounting surface having a smaller diameter than said body of said hub.
8. A decoupler assembly as set forth in claim 7 wherein said hub includes an abutment
20 surface extending radially between said body and said outer mounting surface.
9. A decoupler assembly as set forth in claim 8 wherein said carrier is ring shaped and extends axially between opposite first and second sides.

10. A decoupler assembly as set forth in claim 9 wherein said helical second slot is formed in one of said first and second sides of said carrier for retaining therein said carrier end of said torsion spring for preventing relative movement between said carrier end of said torsion spring and said carrier.

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11. A decoupler assembly as set forth in claim 10 wherein clutch spring extends between a hooked proximal end and an opposite distal end.

12. A decoupler assembly as set forth in claim 11 wherein at least one of said first and
10 second ends of said carrier includes a hooked slot for retaining therein said hooked proximal end of said clutch spring to prevent relative movement between said hooked proximal end of said clutch spring and said carrier.

13. A decoupler assembly as set forth in claim 12 wherein said clutch spring is formed
15 from an uncoated spring steel material.

14. A decoupler assembly as set forth in claim 13 wherein said clutch spring includes a non-circular cross-section to improve frictional engagement between said plurality of coils and said inner surface of said pulley.

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15. A decoupler assembly as set forth in claim 14 including a bearing member operatively assembled between said pulley and said hub for rotatably mounting said pulley on said hub.

16 A decoupler assembly as set forth in claim 15 wherein said decoupler assembly
25 includes a first lubricant operatively associated with said bearing member for minimizing

frictional wear therein and a second lubricant disposed between said clutch spring and said inner surface for minimizing wear therebetween, said second lubricant being compatible with said first lubricant such that said the decoupler continues to function if said first lubricant is displaced from said bearing member and mixes with said second lubricant between said clutch spring and said inner surface.

17. A decoupler assembly as set forth in claim 16 wherein said bearing member includes a ball bearing assembly having an inner race engaging said hub and an outer race engaging said pulley.

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18. A decoupler assembly as set forth in claim 17 including a thrust washer seated on said outer mounting surface of said reduced diameter portion for axially compressing said torsion spring between said carrier and said hub.

15 19. A decoupler assembly as set forth in claim 18 wherein said inner race of said ball bearing assembly is press fit onto said outer mounting surface of said reduced diameter portion to retain said thrust washer against said abutment surface, whereby said axial compression of said torsion spring is maintained.

20 20 A decoupler assembly as set forth in claim 19 wherein said carrier includes a split to allow said carrier to flex and accommodate loads associated with rotation of said decoupler assembly.

21. A decoupler assembly for transferring torque between an engine driven crankshaft shaft and a drive belt, said decoupler assembly comprising:

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a hub configured to be fixedly assembled to the crankshaft;

a spring support fixedly secured to said hub, said spring support having a first tab extending outwardly therefrom;

5 a carrier rotatably mounted on said hub, said carrier having a second tab extending outwardly therefrom;

a torsion spring extending between a hub end and a carrier end for transferring torque between said spring support and carrier, wherein said hub end includes a first notch engaged with said first tab to prevent relative rotation between said hub end of said torsion spring and said spring support and said carrier end includes a second notch engaged with said second tab
10 to prevent relative rotation between said carrier end of said torsion spring and said carrier.

a pulley rotatably coupled to said hub, said pulley having an outer periphery configured to frictionally engage with the drive belt, said pulley having an inner surface formed therein;

a clutch spring fixedly secured to said carrier and having a plurality of helical coils
15 frictionally engaging with said inner surface of said pulley to selectively couple said hub and pulley, said torsion spring and said clutch spring wound in opposite senses enabling said clutch spring to expand into gripping engagement with said inner surface during acceleration of said hub relative to said pulley and to contract out of gripping engagement with said inner surface during deceleration of said hub relative to said pulley.

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22. A decoupler assembly as set forth in claim 21 wherein said hub includes a body extending between first and second ends.

23. A decoupler assembly as set forth in claim 22 wherein said hub includes a reduced diameter portion defining an outer mounting surface having an outer diameter smaller than said body.

5 24. A decoupler assembly as set forth in claim 23 wherein said hub includes an abutment surface extending between said outer mounting surface and said body.

25. A decoupler assembly as set forth in claim 24 including a flange having a mounting portion configured for fixedly mounting said flange onto said outer mounting surface.

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26. A decoupler assembly as set forth in claim 24 wherein said flange includes a U-shaped cross section defined by an end wall extending between inner and outer flange walls.

27. A decoupler assembly as set forth in claim 26 wherein said carrier is retained between
15 said inner and outer flange walls and said end wall, such that said carrier and said clutch spring rotate together with said flange.

28. A decoupler assembly as set forth in claim 27 wherein said pulley includes an inner flange portion having a U-shaped cross section defined by a connecting wall extending
20 between outer and inner pulley walls.

29. A decoupler assembly as set forth in claim 28 wherein said spring support is retained between said outer and inner pulley walls and said connecting wall, such that said spring support rotates with said pulley.

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30. A decoupler assembly as set forth in claim 29 including a thrust washer disposed between said mounting portion of said flange and said abutment surface for continuously biasing said first and second tabs of said spring support and carrier toward engagement with said first and second notches of said hub and carrier ends of said torsion spring, respectively.

Abstract

A decoupler assembly for transferring rotary movement between an engine driven shaft and a serpentine belt. The decoupler includes a hub configured to be assembled to the shaft. The hub has a helical first slot formed therein. A pulley is rotatably coupled to the hub. A carrier is mounted on the hub and includes a helical second slot formed therein, as well as an anti-ramp up boss formed thereon. A thrust plate is fixed to the hub and has a slot formed therein. A torsion spring is compressed between a hub end retained in the helical first slot and a carrier end retained in the helical second slot for transferring torque between the hub and carrier. The anti-ramp up boss travels within the slot formed in the thrust plate for limiting rotation between the carrier and thrust plate and preventing rotation of the torsion spring relative to the hub and carrier.

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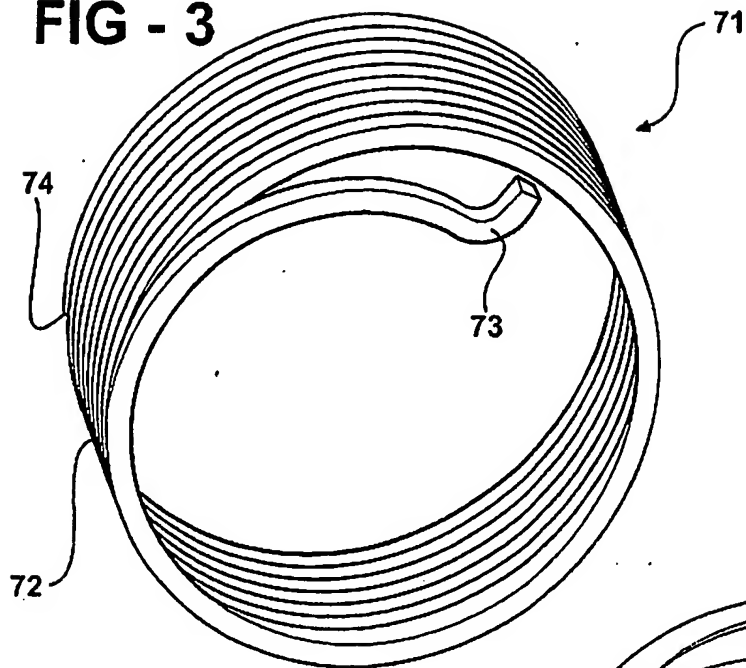
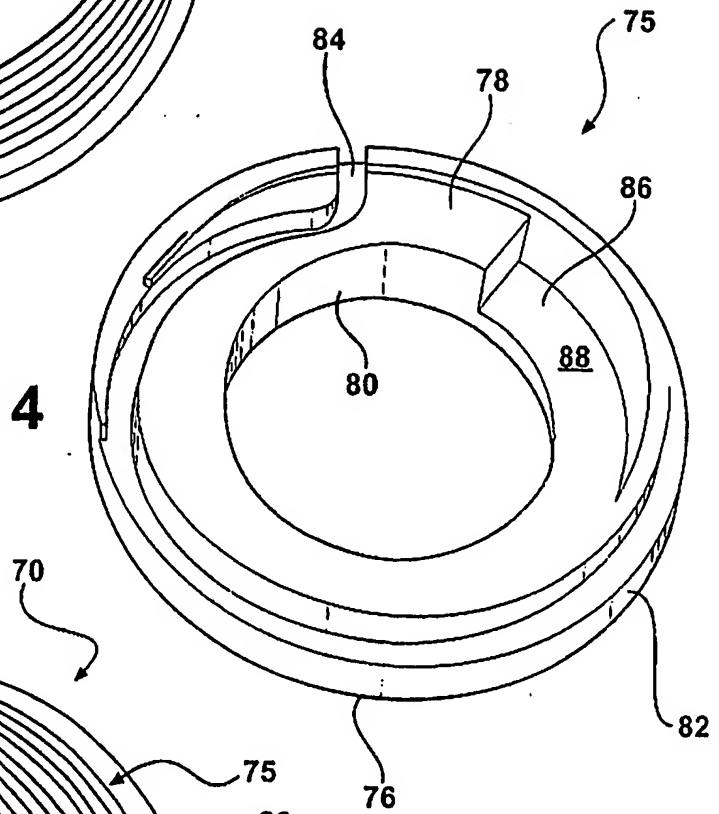
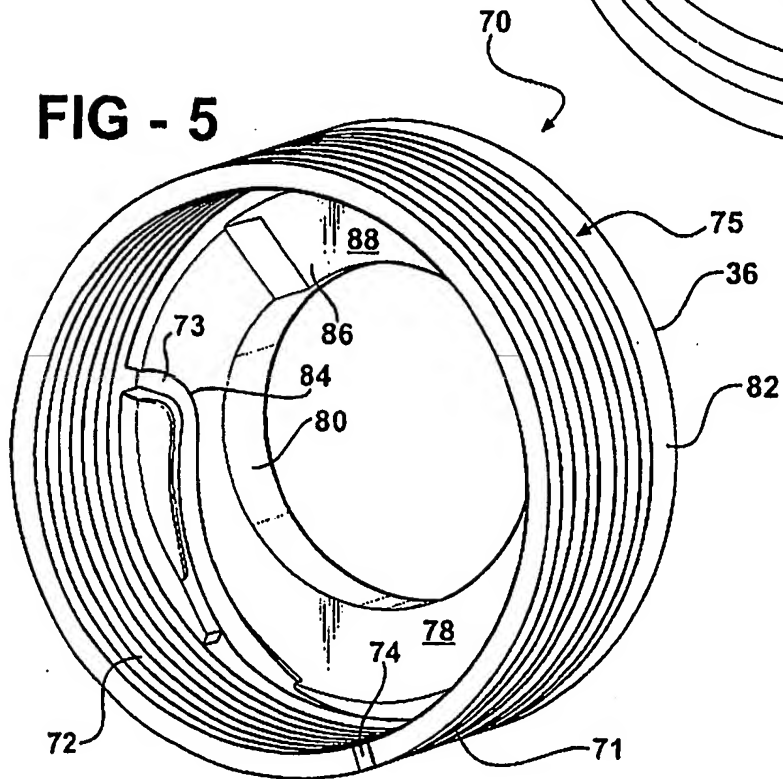
FIG - 3**FIG - 4****FIG - 5**

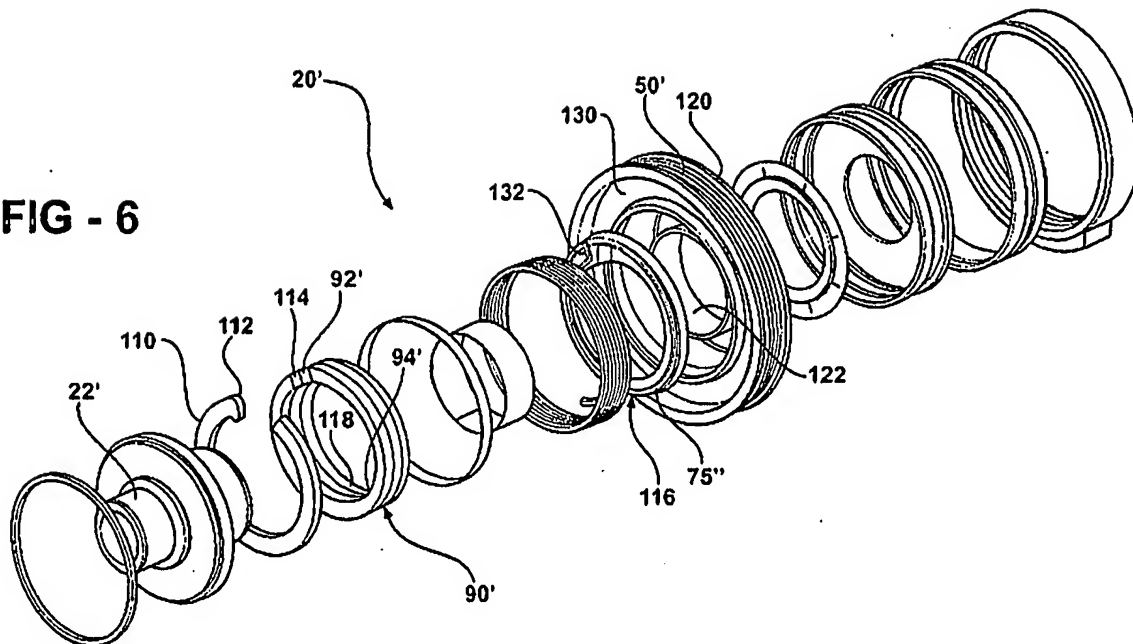
FIG - 6

FIG - 7

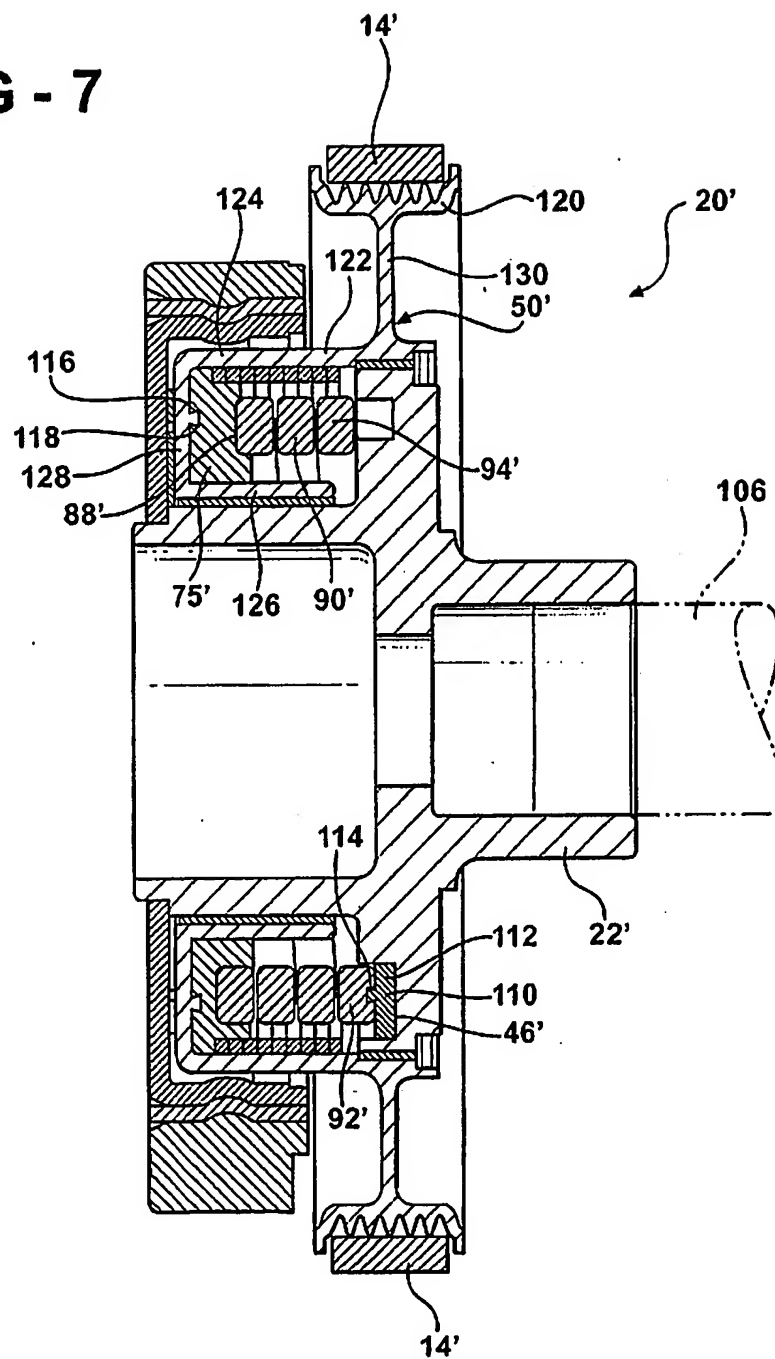
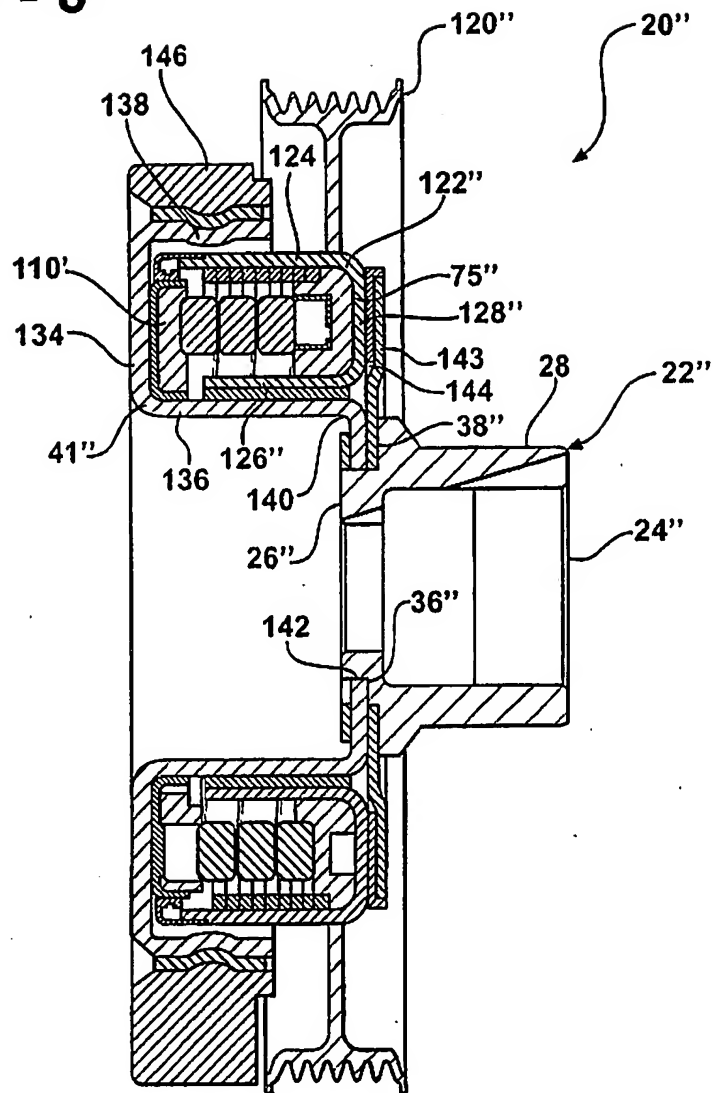


FIG - 8

A. CLASSIFICATION OF SUBJECT MATTER

IPC 7 F16D41/20

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 7 F16D

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the International search (name of data base and, where practical, search terms used)

EPO-Internal, WPI Data, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 6 083 130 A (MEVISSIN PIERRE A ET AL) 4 July 2000 (2000-07-04) cited in the application	1-15
Y	column 22, line 51 - column 25, line 57	16-20
A	figures 15,16,22-24	21-26
Y	WO 01 92746 A (BABCOCK BRYCE ;FRAYER ROBERT (US); MILLER JOHN (US); KING RANDALL) 6 December 2001 (2001-12-06) abstract page 5, line 5 - line 22 figures 2,3	16-20
A	US 5 437 205 A (TSENG SHENG-TSAI) 1 August 1995 (1995-08-01) abstract figures 2,3	21

☐ Further documents are listed in the continuation of box C.☒ Patent family members are listed in annex.

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INTERNATIONAL SEARCH REPORT

Information on patent family members

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